8.0 MITIGATION MEASURES

8.1 Introduction

Many of the predicted adverse impacts of the project on the environment, as discussed in **Chapter 7**, may be mitigated or minimised through various means. Some of these measures are:

i. Proper planning and execution of works during construction.
ii. Selection of up- to- date processes / best management practices (BMPs) for the construction works to reduce noise, air pollution and environmental hazards.
iii. Incorporation of pollution control or pollution abatement measures to reduce waste generation and other adverse impacts during the operation.

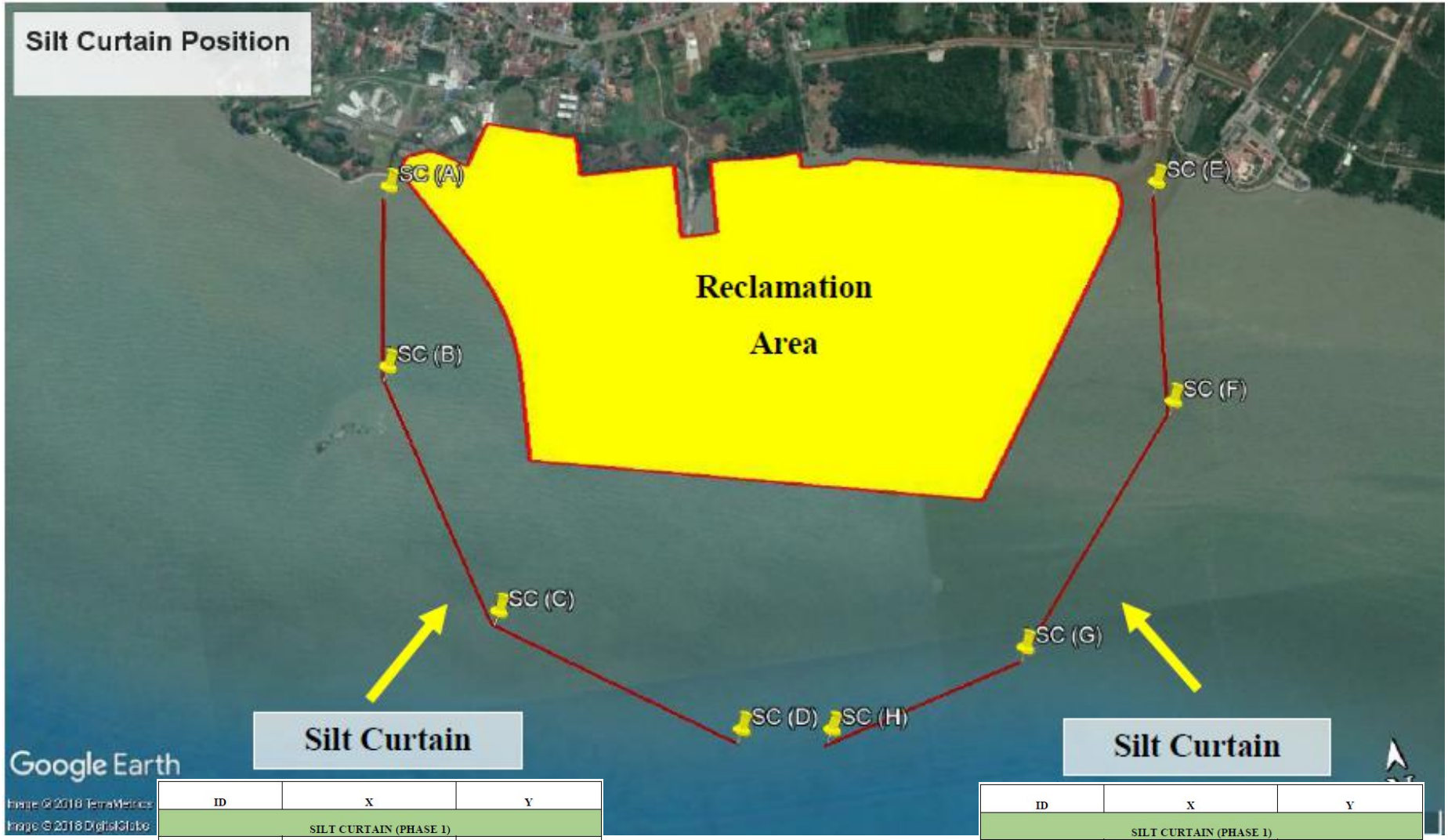
This Chapter discusses the various mitigating measures which can be taken or which can be incorporated into the development process to minimise adverse environmental impacts.

8.2 Hydraulic and Hydrodynamics

8.2.1 During Construction

Installation of Silt Curtain

Silt curtains are vertical barriers positioned within the water to contain fine material (sediment) introduced into the water column by dredging, filling or other engineering construction activities. A definition of a silt curtain is "a floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water". This barrier aims to prevent the fine grained suspended material from migrating by advection and diffusion from the point of generation at the work site and into the wider environment. This fine grained material may reduce water quality and impact upon sensitive receivers in the vicinity of the work site area. **Figure 8.1** and **Figure 8.2** display the proposed silt curtain position during reclamation work (for proposed Phase 1 and Phase 2).



ID	X	Y
SILT CURTAIN (PHASE 1)		
SC (A)	102.319761°	2.156791°
SC (B)	102.319221°	2.152983°
SC (C)	102.320856°	2.147542°
SC (D)	102.325589°	2.144376°

ID	X	Y
SILT CURTAIN (PHASE 1)		
SC (E)	102.335983°	2.154587°
SC (F)	102.335629°	2.149921°
SC (G)	102.331756°	2.145229°
SC (H)	102.327464°	2.144110°

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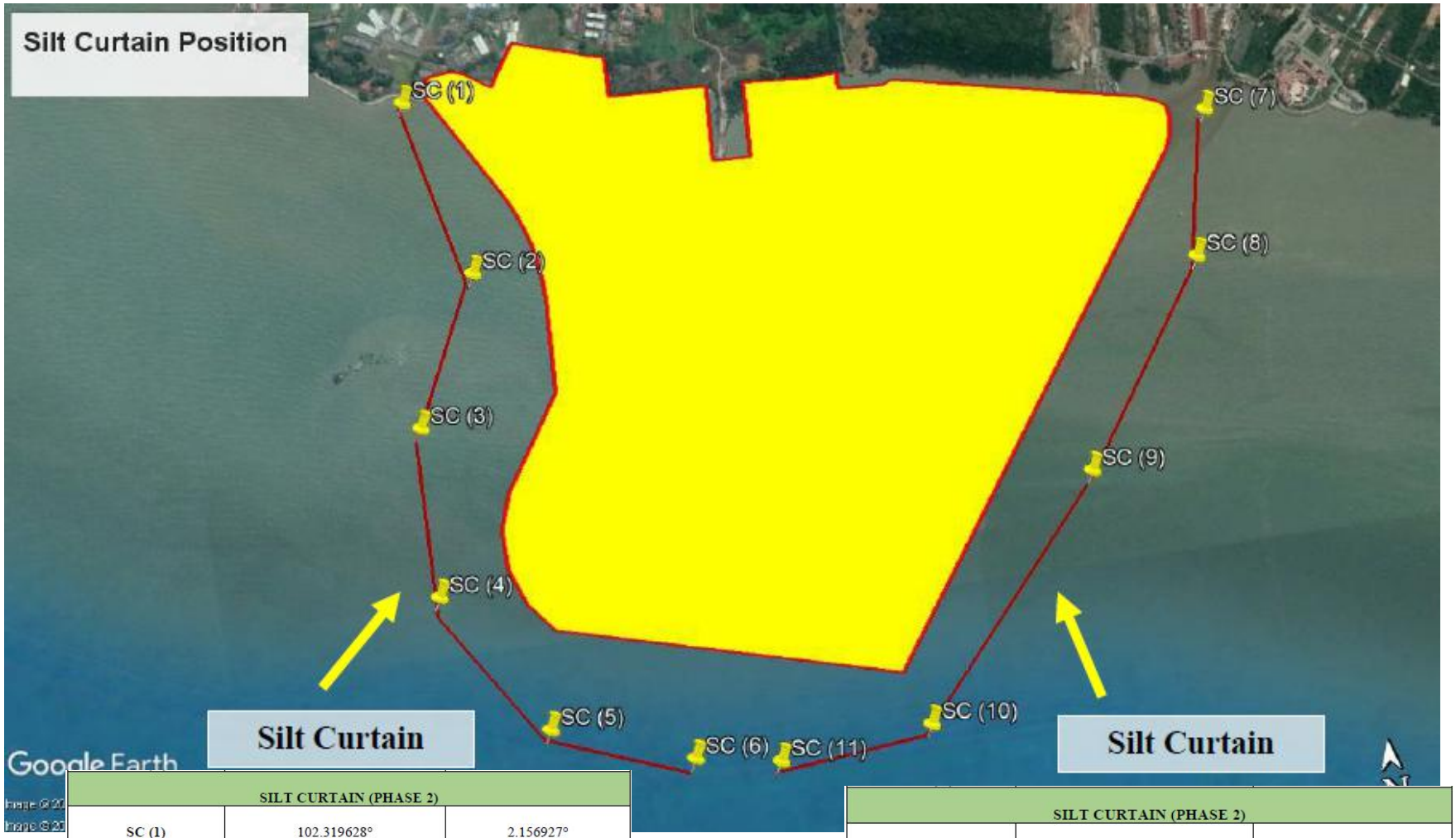
Source : Approved Hydraulic Report

Figure 8.1: Proposed Silt Curtain Position During Reclamation (Phase 1)



SILT CURTAIN (PHASE 2)		
SC (1)	102.319628°	2.156927°
SC (2)	102.320592°	2.153251°
SC (3)	102.319130°	2.150266°
SC (4)	102.319061°	2.146831°
SC (5)	102.320933°	2.143896°
SC (6)	102.323742°	2.142927°

SILT CURTAIN (PHASE 2)		
SC (7)	102.335922°	2.154503°
SC (8)	102.335298°	2.151542°
SC (9)	102.332528°	2.147523°
SC (10)	102.328554°	2.142943°
SC (11)	102.325439°	2.142632°

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Source : Approved Hydraulic Report

Figure 8.2: Proposed Silt Curtain Position During Reclamation (Phase 2)

Alternatively, a cheaper option is to construct bund and revetment within a limited length of silt curtain enclosure and to repeat the process until the whole length of the reclaimed perimeter is completed. Filling works can then be proceeded continuously. The completed revetment shall then act as a barrier to restrict sediment plume from dispersing outside of the revetment. A double layer silt curtain will definitely be more effective in restricting the dispersion plume within the work area.

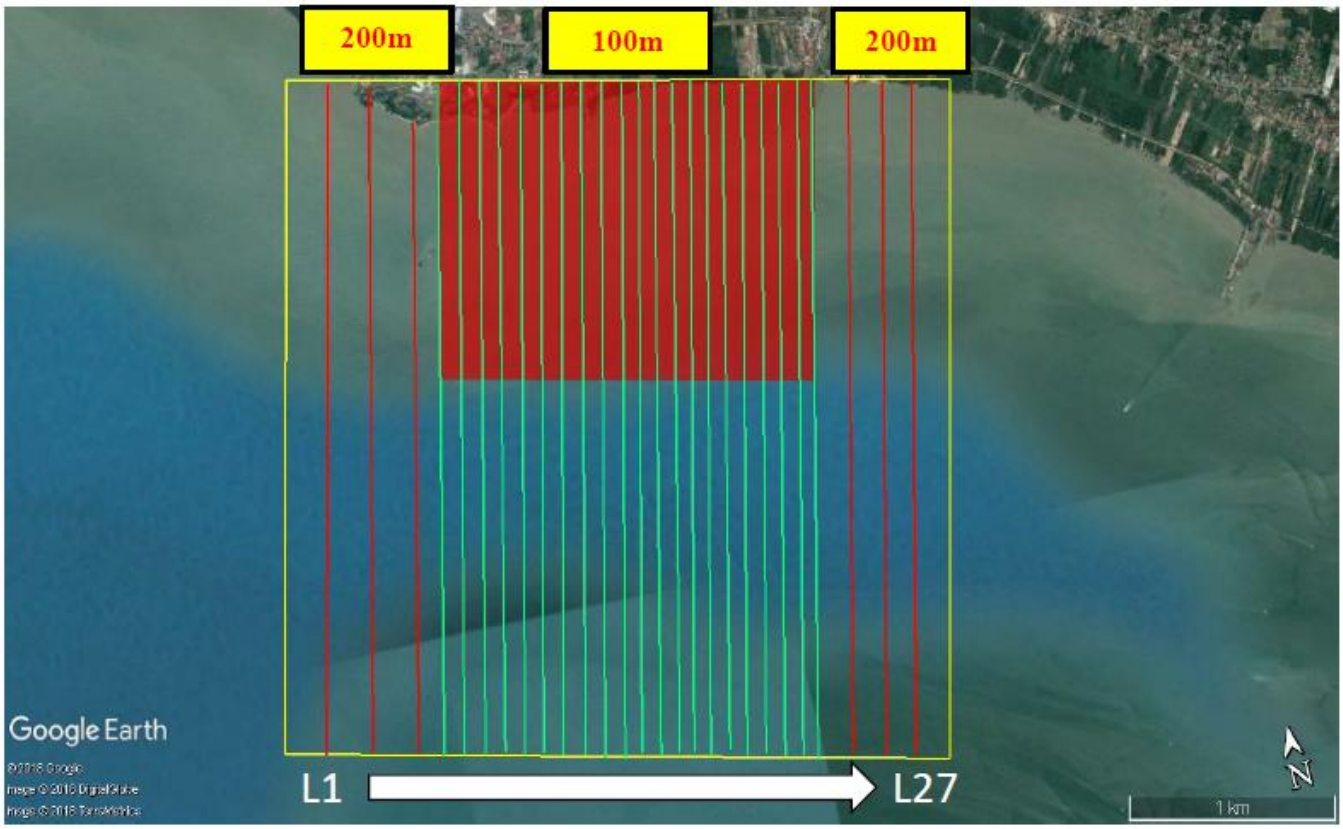
The reclamation phasing plan and silt curtain position mentioned in this report are only a proposal. The final phasing plan and silt curtain position will be discussed in greater detail during the EMP stage prior to the commencement of work, when the appointed reclamation contractor has been officially appointed.

Coastal Monitoring Programme

Coastal monitoring programme is one of the components that is required by Drainage and Irrigation Department (DID) for reclamation work. The proposed monitoring programme is important to identify, if any, additional mitigation measures that may be needed after the reclamation works. The land survey and bathymetry survey are the main component of the coastal monitoring programme. These surveys are required to ensure that there are no changes to the surrounding coastal environment due to the reclamation works. The survey lines would be designed at two different intervals i.e. 100 meter interval and 200 meter interval. Erosion and deposition patterns would need to be monitored using topographical and hydrographic surveys. Random survey plan line is proposed throughout the monitoring period as shown in **Figure 8.3**. Monitoring would be executed at three month interval during the reclamation works at the project site.

8.2.2 Post Reclamation

A coastal monitoring programme is also required to be done after the completion of the reclamation works. It would have to be conducted every 6 months for a 3 year period after the completion of the reclamation works. Details of this requirement can be found in the Hydraulic Study approval letter in **Appendix V**.



LINE	MONITORING SURVEY LINE			
	START POINT		END POINT	
	X	Y	X	Y
L1	102.316	2.16014	102.309	2.13299
L2	102.317	2.15855	102.311	2.13253
L3	102.319	2.1575	102.313	2.13205
L4	102.32	2.15737	102.314	2.13178
L5	102.321	2.15727	102.315	2.13158
L6	102.322	2.15689	102.316	2.13136
L7	102.322	2.15632	102.317	2.13116
L8	102.324	2.15739	102.317	2.13095
L9	102.324	2.15664	102.318	2.13077
L10	102.325	2.15666	102.319	2.13055
L11	102.326	2.15657	102.32	2.13032
L12	102.327	2.15653	102.321	2.1301
L13	102.328	2.15647	102.322	2.1299
L14	102.329	2.15655	102.322	2.12974
L15	102.329	2.15649	102.323	2.12954
L16	102.33	2.1565	102.324	2.12936
L17	102.331	2.15638	102.325	2.1292
L18	102.332	2.15619	102.325	2.12901
L19	102.332	2.15601	102.326	2.12881
L20	102.333	2.15576	102.327	2.12863
L21	102.334	2.15567	102.328	2.12843
L22	102.335	2.15555	102.328	2.12823
L23	102.336	2.15536	102.329	2.12805
L24	102.336	2.15521	102.33	2.1279
L25	102.338	2.1545	102.331	2.12753
L26	102.339	2.15422	102.333	2.12718
L27	102.34	2.15396	102.334	2.12687

8.3 Hydrology

8.3.1 During Construction

It is of great importance to ensure that any existing outlet channel at the site and its surroundings are not blocked during both the construction and operation phases of the project. Blockage of any outlet can lead to occurrence of floods in the area. If there are many outlets from this area, it is advisable to provide a natural drain between the reclaimed area and the existing coastline so that all the existing outlets can discharge directly into this drain.

In this case, impact is foreseen at the Kg. Pernu outlet drain which is located immediately to the north of the project site, as explained in the preceding chapters. It is hence suggested that the Kg. Pernu outlet be maintained and that a channel is provided between the project site and the existing coastline (see **Figure 7.10** in **Chapter 7**). Rock revetment will be constructed as the slopes of this channel. Design of the rock revetment is as attached in **Appendix XIV**. Periodic maintenance dredging should be conducted every 6 months at the proposed channel throughout the construction period.

8.3.2 Post Reclamation

As mentioned above, a channel would be provided for a continuous flow of the Kg. Pernu drain. This channel requires maintenance dredging to be done in order to maintain a sufficient depth and area over time. Upon completion of the reclamation works, maintenance dredging should be undertaken to ensure sufficient depth and width of the channel. With the rock revetment constructed as the slope of the channel, sediments are only expected to come from external areas outside the project site. Once the Defects Liability Period has ended, the channel maintenance is expected to be done by the relevant authorities. A disposal site for the dredged material would also have to be identified. Further discussion regarding the disposal site will have to be done subsequently.

8.4 Waste Generation

8.4.1 Solid Waste

During Construction Phase

It is important that solid waste management is undertaken throughout the construction and operational phases of the development using appropriate methods.

As of 1st September 2015, the Malaysian Government has made it mandatory to separate solid waste at source. The implementation is pursuant to regulations under Solid Waste and Public Cleansing Management Act 2007 (Act 672). Hence, it is compulsory for the project proponent to ensure that separation of solid waste at source is implemented throughout the construction and operational phases of the project.

i. Domestic Waste from Workers Camp

Waste generated by the workers camp should be collected and disposed at any approved landfill site. Proper containers and garbage bins should be provided at the workers camp and regularly collected. Enforcement on littering would need to be executed to ensure the site is in proper and clean condition.

ii. Construction Waste / Unwanted Construction Material

One of the significant waste streams expected during the execution of the project is surplus and unwanted construction materials. These materials, such as reinforcement bar, excess concrete and plastic boards should be disposed off at a designated landfill site. Before disposal, waste should be sorted to identify reusable material. This would reduce the volume of waste. Liquid wastes such as oil and grease, chemical solutions etc. should also be separated from solid wastes before disposal at a designated landfill site. A policy on waste reduction and waste recycle should be adopted by the contractors in line with the National Solid Waste Policy.

Post Reclamation Phase

No solid waste will be generated upon completion of the reclamation works.

8.4.2 Scheduled Waste

Any waste which is listed in the First Schedule of the Environmental Quality (Scheduled Wastes) Regulations 2005, either during construction phase or operational phase, must be handled or managed in accordance to the Environmental Quality (Scheduled Wastes) Regulations 2005. To ensure the predicted impacts as described in **Chapter 7** could be mitigated more effectively, the following emphasis should be adopted and practised for each phase of the development.

During Construction Phase

i. Maintenance of machineries during construction phase will generate spent oil (lubricating oil and hydraulic oil). These spent oils are categorized as scheduled waste under codes SW305 and SW306 in the Environmental Quality (Scheduled Waste) Regulations 2005. The waste oils should be stored in 200 L drums and collected by licensed scheduled waste contractor approved by DOE for recycling or disposal.

ii. Temporary storage facilities for scheduled waste should have an impermeable floor, be bunded and covered with a simple structure of roofing to protect the container from the weather. The capacity of the containment should be 110% of the largest container stored or 25% extra storage capacity of the actual maximum amount of waste generated. All containers must be labelled and routinely inspected for leaks in a regular interval.

iii. The storage area for scheduled waste should;
   - be enclosed on at least 3 sides;
   - have adequate ventilation;
   - be covered to prevent rainfall from entering (water collected within the bund must be tested and disposed off as scheduled waste, if necessary); and

- be arranged so that incompatible materials are appropriately separated;
- have a signboard set up with the word DANGER, painted with a letter size of 30 cm on a bright yellow background at the entrance of the storage site.

During Operational Phase

Scheduled waste is not expected to be present after completion of the reclamation works.

8.5 Water Quality

For each of the evaluated significant impacts, there should be preventive and abatement measures to prevent and reduce the adverse impacts. Mitigation measures may require selection of methods of transportation and construction, timing, engineering design, etc. Other forms of mitigation may include pollution control such as silt curtain, waste treatment, phased implementation and construction, engineering measures, landscaping, restoration and environmental monitoring.

The following are parts of the mitigating measures on water quality during reclamation and post-reclamation.

8.5.1 Turbidity/ Suspended Solids

In order to prevent the sediment plume during filling process for reclamation, mitigation measures may include construction of proper containment structures prior to the disposal of fill material, controlled operations with the latest environmental friendly dredging technologies coupled with the installation of silt curtains where necessary.

Silt curtains are vertical barriers positioned within the water to contain fine material (sediment) introduced into the water column by dredging or other engineering construction. A definition of a silt curtain is "A floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water". This barrier aims to prevent the fine grained suspended material from migrating by advection and diffusion from

the point of generation at the work site and into the wider environment. This fine grained material may reduce water quality and impact upon sensitive receivers in the vicinity of the work site area. **Figures 8.1 and 8.2** displays the silt curtain position during reclamation work (adopted from Coastal Hydraulic Study, Final Report, 2018). By installing double layer silt curtains, the sediment dispersion plume is restricted within the reclamation area. At the same time, regular water quality monitoring is essential to monitored the efficiency of silt curtain. At the post reclamation stage, removal of the silt curtain should be conducted by trained workers. Fine sediment must be removed before removal of silt curtain.

An alternative option would be to construct bunds and revetments within a limited length of reclamation footprint and to repeat the process until the whole length of the reclaimed perimeter is completed. Filling works can then be proceeded continuously. The completed revetment would then prevent the sediment plume from dispersing outside of the revetment.

Overall stability of the reclaimed area must be adequately proposed in terms of standard engineering practices undertaken during and after construction stage. Placement of rock revetment should be carried out with proper operating procedures.

8.5.2 Oil & Grease

In the event of oil spill, badly contaminated soil should be collected and properly disposed according to the Environmental Quality (Scheduled Wastes) Regulations, 2005. No effluent or wastewater from the base camp should be discharged into the sea without prior treatment.

Discharge of oily wastewater from sea vehicles' engine room should be channelled into the oil separator. The waste oil should then be stored in slop tanks and managed as scheduled waste according to Environmental Quality (Scheduled Wastes) Regulations, 2005.

8.5.3 Wastes (Solid Wastes, Effluents and Wastewater)

Providing sufficient number of mobile toilets and treating the effluent from the toilets and the sullage in self-contained septic tank system will minimise potential pollution of surrounding water bodies by wastewater.

Left over wastes should be collected by contractor and properly disposed off in a designated landfill site approved by the local authority. The project managers must handle garbage and solid waste collection. The wastewater discharges should comply with Standard A of Environmental Quality (Sewage) Regulations, 2009.

8.5.4 Nutrients

In the course of project operation, if nutrients in the water are found to exceed the limit stated in the MMWQS, the latest state of the technology available should be adopted as part of the mitigating measures. Thus, frequent seawater quality monitoring during operation should be conducted to assist in identifying any adverse conditions.

The fill material dredged from the sand source area should only be used for reclamation at the project site and not to be disposed elsewhere. The application of a reliable global position system (GPS) device will ensure exact positioning of vessels while releasing the fill material.

8.6 Air Quality

8.6.1 During Construction Phase

i. Water Dampening Operation

Vehicular movements, particularly during mobilization of machineries and material transportation, can give rise to significant fugitive dust when vehicles are eggressing and ingressing the project area. Dust generation is due to the force of wheels on the road surface, which causes pulverisation of surface material. Control of dust is best done by ensuring the particles adhere to each other and do not become separated easily. This could be done by water dampening operation on the exclusive access to ensure that this road remain slightly wet during use. Water dampening operations are best to be carried out using a water tanker equipped with a sprinkler nozzle. Using the sprinkler nozzle, water droplets could be scattered more thoroughly on the road surface without giving rise to an over dampened situation that might create another problem to the surrounding road system, viz., muddy road.

ii. Speed Limit of The Moving Traffic

Since dust generation is also affected by truck speed, a speed limit of the moving traffic in the project site should be imposed. It is recommended that the speed of the moving traffic within the Project site should be restricted to 30 km/hr and this could also ensure the safety within the project site. Signboards indicating the maximum permissible speed limit should be in place and enforcement on the speed limit shall be practiced by the project management.

iii. Tyre Washing Operation

If the trucks need to be moved outside the project site into public roads, tyre washing operation should be adopted at the entrance / exit to the project site. Tyre washing facility should include a high-pressure water jet system and a sump for the collection of washings, settling basin, sediment disposal and water recycling. A typical layout plan of a suitable tyre washing system which could be adopted by the Project Proponent is shown in **Figure 8.4**.

iv. Proper Approach on Transporting Construction Material

Apart from clearing up the tyres, it is also recommended that all trucks carrying construction materials and transporting earth must be covered securely with canvas before moving out from the project site.

v. Regular Maintenance of Equipment / Machineries

It is important that all the equipment / machineries used during the project implementation be regularly maintained to ensure that they are functioning at their best hence prevent / reduce emission of smoke.

8.6.2 During Operation Phase

No impact on air quality after completion of the reclamation works.

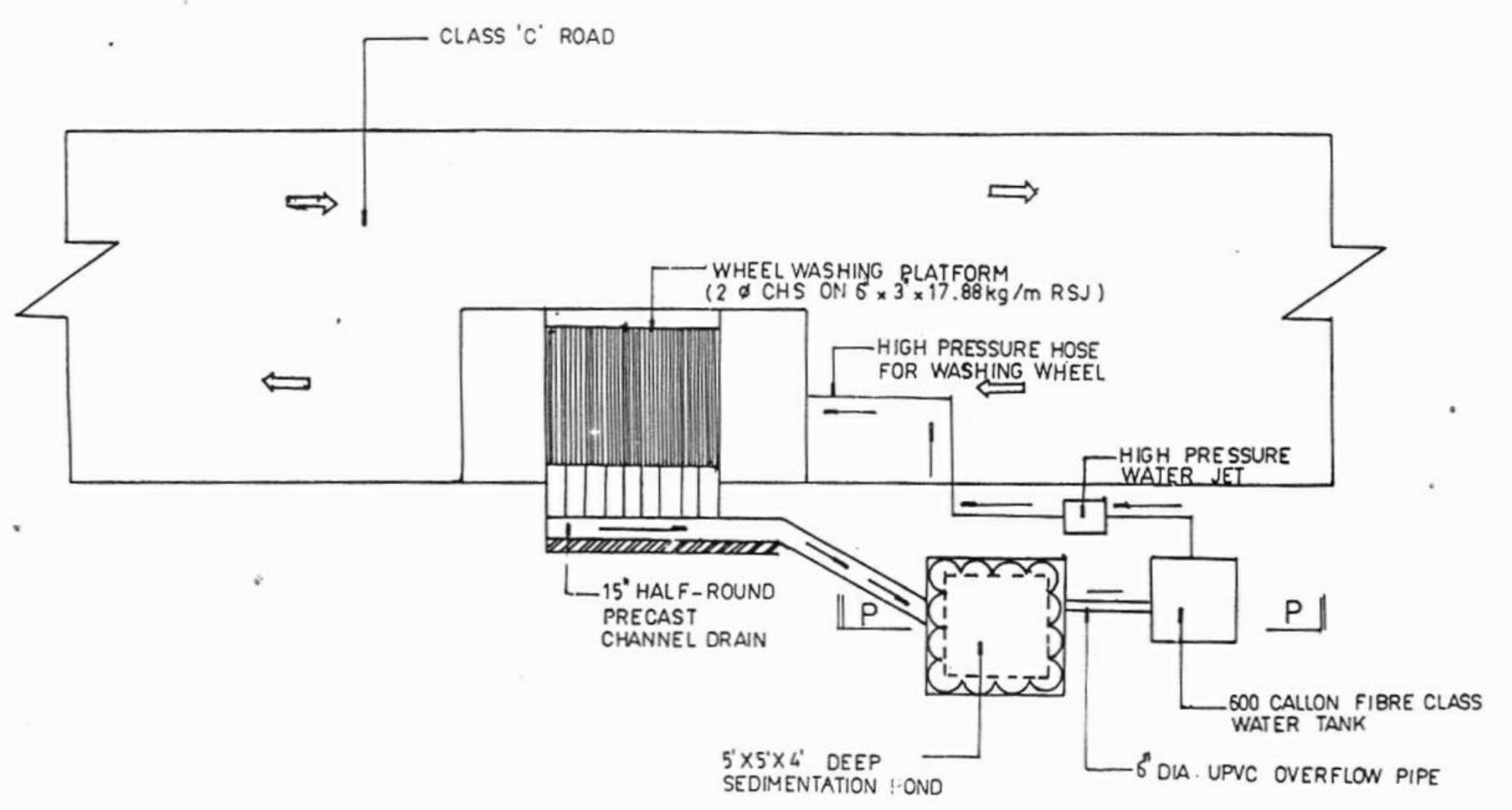


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Figure 8.4: Tyre Washing System

8.7 Noise Level

Noise interference is an environmental problem that is best to control at source. There are many ways to control a static noise source, should it become annoyance to the surrounding environment. However, as for a dynamic source of noise interference such as vehicles movement, practical methods to control noise levels are often difficult. The available methods to control and reduce noise interference related to the stages of development, viz., construction and operation are briefly discussed as below.

8.7.1 During Construction Phase

i. Limit on the Working Hours

Working hours for construction activities should be limited to daylight hours only. It is highly recommended that construction activities should only be allowed from 8.00 am to 6.00 pm and not allowed on rest days e.g. Sunday or public holidays, in consideration of nearby residential areas and villages.

ii. Vehicles Speed Limit Restriction

Noise levels generated from the increase in construction traffic is expected to be significant. However, the impact can be reduced by controlling the speed of the vehicles entering and leaving the Project site. To mitigate excessive noise generated from the Project site, it is also recommended that the speed of the vehicles within the Project site to be restricted to a maximum speed of 30 km/hr.

iii. Provision of Proper Hoarding

Proper hoardings should be placed at the onset of construction, prior to the commencement of the reclamation works. The material used should be an absorbent type, e.g. plywood, so as to absorb excessive noise from the construction activities. A proper selected hoarding should be able to attenuate up to 20 dB(A) so as to ensure the noise level generated can be kept at 60 dB(A). The height of the hoarding should not be less than 2 meters.

8.7.2 During Operation Phase

No noise impact is expected upon completion of the reclamation works.

8.8 Land Traffic

8.8.1 During Construction Phase

The increase in land traffic during construction phase will mostly come from construction vehicles like tippers, dozers, cranes etc. which is temporary. As far as possible, movement of construction vehicles on public roads should be scheduled during off-hours to avoid traffic congestion.

8.8.2 During Operation Phase

There will not be any increase to land traffic after completion of the project.

8.9 Marine Traffic

8.9.1 During Pre-Reclamation Phase

The Project Proponent and the contractors should communicate with Marine Department Melaka Tengah, Melaka Port Authority, Department of Fisheries Melaka and Persatuan Nelayan Melaka on project activities (especially marine spread activities) within port limits and Proposed Project areas. At the same time, they should send out early notification (2 weeks before commencement) of their activities to the Marine Department so that "Notice to Mariners" can be issued in a timely manner.

The physical presence of permanent anchorage or platforms should be registered and marked on the Admiralty Chart to ensure mariners are aware of the project. Work areas should be properly delineated so as to avoid encroachment into existing fishing grounds. Highly visible

and lighted buoys should be stationed at the project site to warn other users, particularly fishermen, of the project site and activities.

8.9.2 During Reclamation Phase

i. Maritime Traffic

During the reclamation phase, detailed route planning should be closely monitored to prevent any congestion. All vessel movements in the vicinity should be with the permission and under the guidance of the port control or vessel traffic control station in order to ensure effective traffic management system. They must have adequate navigational lights and signals to provide sufficient warning to vessels using the waterway to avoid any incidents. They must adhere to the Rules of the Road (COLREG), SOLAS and STCW regulations. A high standard of seamanship and vessel management on the part of contractor associated with the project can ensure a high standard of safety and good seamanship.

Before start-up of this project, all vessels involved in this reclamation activities should obtain clearance from Marine Department Malaysia by providing vessel particulars, operating licenses and seafarer documents. Also, in order to assist in collision avoidance, it would be compulsory for vessels to install Automatic Identification System (AIS) and Dredging & Dumping Monitoring System (DDMS) to record the traversing path.

All supporting vessels should be maintained frequently to prevent unnecessary break downs that would eventually draw in more vessels to repair the impaired vessel consequently leading to increased traffic volume around the area. Supporting vessels, tug boats and tankers should follow planned route to minimize disturbance to normal traffic in the area. Anchoring by supply or other vessels operating in the area should take cognizance of the fact that there are other features, especially in the Straits of Malacca, that could be susceptible to anchor damage or anchor dragging.

As reported by Marine Department officers and port authorities, their past experiences have recorded crew working on operating vessels did not have the requisite command of local working languages. This caused problems since they did not then adhere port rules or local regulations, practicing agreements reached with local authorities and fishermen, and breaking

navigational rules. The project proponent must ensure that their contractors have competent mariners that can communicate in English or Bahasa Malaysia to ensure that the above issues can be amicably resolved.

ii. Fisheries Activities

Prior to project implementation, public involvement exercises should be conducted to explain to the fishing community to allay any concerns they may have. Project proponents should have constant discussions with the fishing community through the Persatuan Nelayan and LKIM to address their issues, and appropriate mitigation measures to address them.

Among these include provision for employment in the project, provision of alternative fishing sites by construction of fish aggregating devices, retraining of fishermen to take up alternative careers, and provision of business opportunities. As a last resort, suitable amount of compensation to fishermen who have lost their fishing grounds and have to travel further away to catch fish should be considered. Contractors or related authorities should help to warn fishermen of ongoing operations, to ensure that fishing vessels and other vessels do not encroach into the project area or otherwise interfere with the reclamation equipment and operation. Advanced warning and consultation with the relevant authorities can help to prevent any disruption to fishing activities in the area or project operation.

Furthermore, the presence of workers at the project site would generate sewage, sullage and garbage. Improper disposal of garbage and other affluence will pollute the marine water. Also, the construction works are expected to produce a substantial amount of construction waste, such as plastic, which it will be a risk to marine animals if they are accidentally or intentionally dumped into the sea. All waste should be properly packed and brought to shore while any oily and scheduled waste to be disposed by competent contractors ashore.

iii. Anchoring – Physical Environment

The Project Proponent should monitor the detailed route planning of vessels movement and the anchorage activities to prevent any damage to the environment. The development might affect the traffic, which increase the number of vessels in Melaka coastal area. Thus any

vessels must follow the suitable route and place the vessels at specific anchorage area to ensure a high standard of safety and minimize seabed disturbance effects.

iv. Anchoring - Underwater Noise

The Project Proponent and contractors must adhere to related guidelines to ensure fish and other marine life are absent from the immediate vicinity of the project area. A soft start of operation may be needed in order to minimise risk of physical injury and behavioural impacts to fisheries and marine environment.

v. Activities Using Tugboats and Barge Positioning – Noise

It is advisable for workers to use sound protection gear or ear muffs in order to avoid any negative impact to them. Regular maintenance is necessary to ensure the instruments and machines are in good condition. Adjusting of variables following the weekly and monthly schedule, lubrication of the joints, good alignment of stern contour of the vessel and tightening of the bolts are the most effective ways to noise and vibration control.

vi. Activities Using Tugboats and Barge Positioning – Air Pollution

As explained in **Chapter 7**, emissions can be expected from the machineries / supporting vessels used during the project implementation. Although emissions will be quickly dispersed, but still a constant monitoring of these emissions and the regular servicing of engines, generators and compressors is a must to ensure that emissions will be kept low.

vii. Activities Using Tugboats and Barge Positioning – Hydrocarbon Spills

To obviate the risk of any oil spillage, it is important that vessels follow the Local Emergency Oil Spill Response Plan and the National Emergency and Oil Spill Contingency Plans during operation. All the vessels berthing and the operational vessels should be thoroughly inspected prior to their initial call at the facility, and at regular intervals thereafter, to ascertain that they fully comply with all the international and local safety standards.

8.9.3 During Post-Reclamation and Development Phase

After reclamation and subsequent development of the site, it is expected that there would be an increase in recreational boating with the existence of residential, commercial, light industrial properties and resorts along the coastline of Umbai area. The project proponent and the related authorities should be well trained in handling potentially catastrophic incidents such accidents that can arise as a consequence of increased boat traffic. The increase of marine traffic will necessitate enhanced control and coordination of vessel movement to ensure effective traffic movement. At this phase, a special delineation of the limited space, route direction timing and speed control would be required to avoid conflict of users at the area.

8.10 Social Impact Assessment (SIA)

8.10.1 Job and Business Opportunities For Local Communities

i. Any boost in local economy would only be effective if a portion of the labour required is recruited from the local communities. For the project to be relevant to the local communities, it should involve at least 30% of locals in the work force recruitment. Local employment can be facilitated through skills training programs for the local communities.
ii. Local contractors and sub-contractors should be similarly given some priority in project construction. Such an approach would not only fulfil the local community expectations but would portray and boost the image of the proponent as being socially responsible.

8.10.2 Livelihood Security

i. To facilitate grievance resolution, particularly among the fishing communities, representatives each from the local Persatuan Nelayan Units within the ZOI should be appointed by the Project Proponent during the reclamation duration to act as liason with the fishing community.

ii. It is proposed that a meeting between the local fishermen association units, the state fishermen's association, LKIM and other related agencies with the Project Proponent be held prior to project implementation. This is necessary to work up a plan of monitoring of reclamation works, long term compensation scheme for loss of fishing areas, and job and business opportunities.

iii. Compensation

- The project proponent should provide compensation to affected fishermen in collaboration with LKIM / Persatuan Nelayan and Department of Fisheries, taking into account considerations, such as the boat type and size, gear, fishing frequency and others.

iv. Local communities should be prioritised for undertaking business ventures such as operating worker's canteen or the general sales of local produce and prepared food in proper kiosks at strategic points nearby the construction area during the construction period.

v. The activities that could cause nuisance to the public such as noise pollution emitted from dredging boats, heavy machinery and piling works should be avoided or minimized. Schedule of work time should be accommodative to the needs of the people.

8.11 Marine Ecology, Fisheries and Aquaculture

8.11.1 Introduction

It is important to note that the reclamation will lead to an irreversible and permanent loss of the natural ecological and economic values of the site being reclaimed though the mitigation measures proposed below can blunt the worst impacts of the reclamation and pre-empt some of the environmental problems associated with its implementation.

8.11.2 Marine Productivity and Marine Habitat

Loss of Foreshore Area and Mudflat as Fisheries Habitat

The loss of the mudflat cannot be fully mitigated. However, the following measures are recommended as offsets:

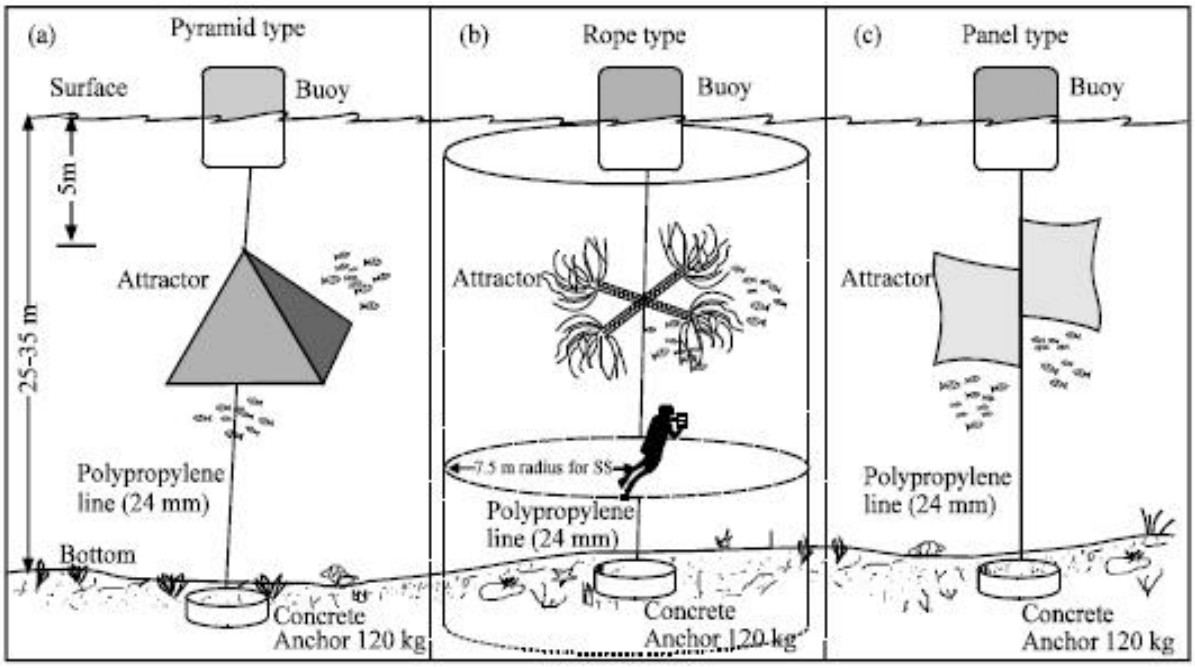
- Installation of Fish Aggregating Devices (FADs) for artisanal and recreational fishing
- Installation of habitat enrichment infrastructure
- Sea ranching
- Fisheries research fund

Details of each proposed mitigation measures are as in the following sub-sections.

8.11.2.1 Installation of Fish Aggregating Devices (FADs) for artisanal and recreational fishing

The installation of FADs would enable aggregation of fish stocks, which, in turn, would reduce the cost of fishing. A study by Altinagac *et al.* (2010) reported increases in the number of fish species (from 10 to 16) before and after the deployment of FADs. With respect to the study area, the water depth is generally shallow, as such, the FAD recommended should be of a static type i.e. fixed to the bottom with anchors. Example of FADs for artisanal and recreational fishing are shown in **Figure 8.5**. However, the detailed design would need to be consistent with site conditions and will be part of a separate study.

Figure 8.5: Examples of FADs for Artisanal and Recreational Fishing



Source: Altinagac et al., 2010

8.11.2.2 Installation of Habitat Enrichment Infrastructure

These would be the infrastructures that would protect and enhance existing habitats, enabling fish stocks to recover from the reclamation to some extent. Among the possibilities would be:

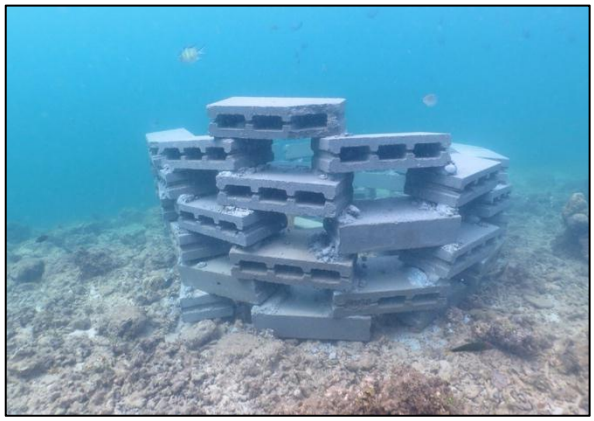
Deployment of Artificial Reefs

Enhancement of the habitat values of existing coral reefs in Pulau Besar, Pulau Serimbun, Pulau Terendak and Pulau Burong through deployment of artificial reefs. Ahmad *et al.* (2013) reported that 76 species of commercial fish, 33 species coral fish, 7 species of soft coral, 6 species of gorgonians, 9 species of gastropods, 8 species of bivalves, 7 species of sea cucumber, 4 species of sponges and 3 species of echinoderms were recorded at artificial reefs installed along the East Coast of Peninsular Malaysia. Example of artificial reefs for habitat enhancement are shown in **Plate 8.1**.

Plate 8.1: Examples of Artificial Reefs for Habitat Enrichment





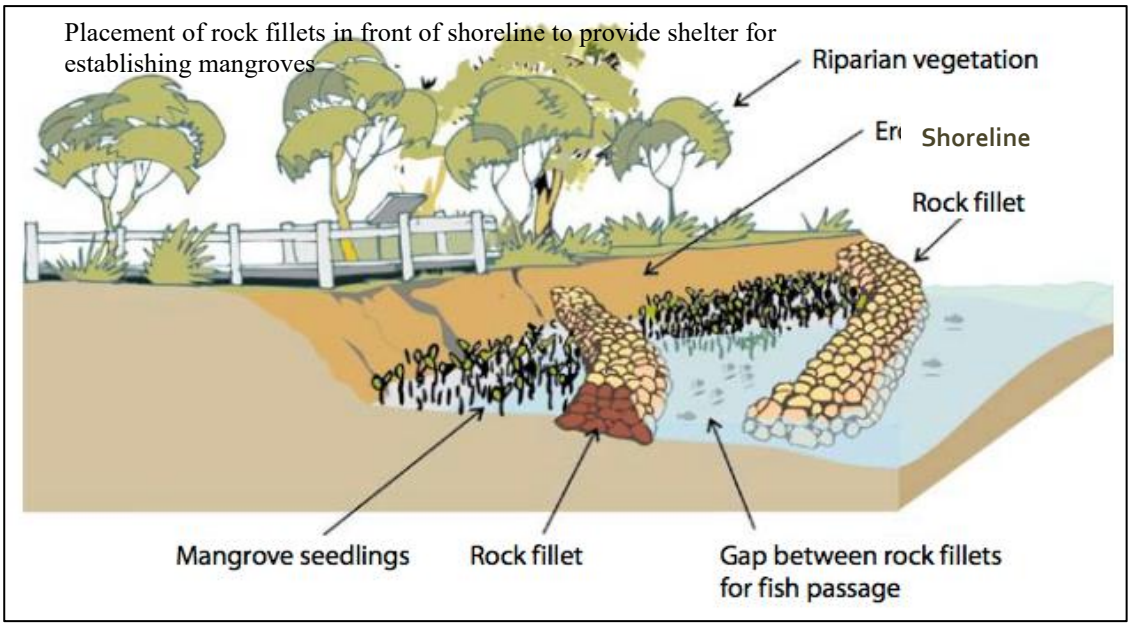



However, the specific design of the artificial reefs and their exact locations would need to be part of a separate study. Apart playing a role as habitat enhancement, artificial reef such as reef balls can be installed off Pulau Besar for turtle conservation as part of the offset programme. Reefs balls have been successfully installed along the coastline of Sarawak and proven their effectiveness in protecting critical habitats (internesting swimming areas, nesting beaches and feeding ground) and migration routes of turtles.

Construction of Eco-engineered Structures for Habitat Enhancement and Creation

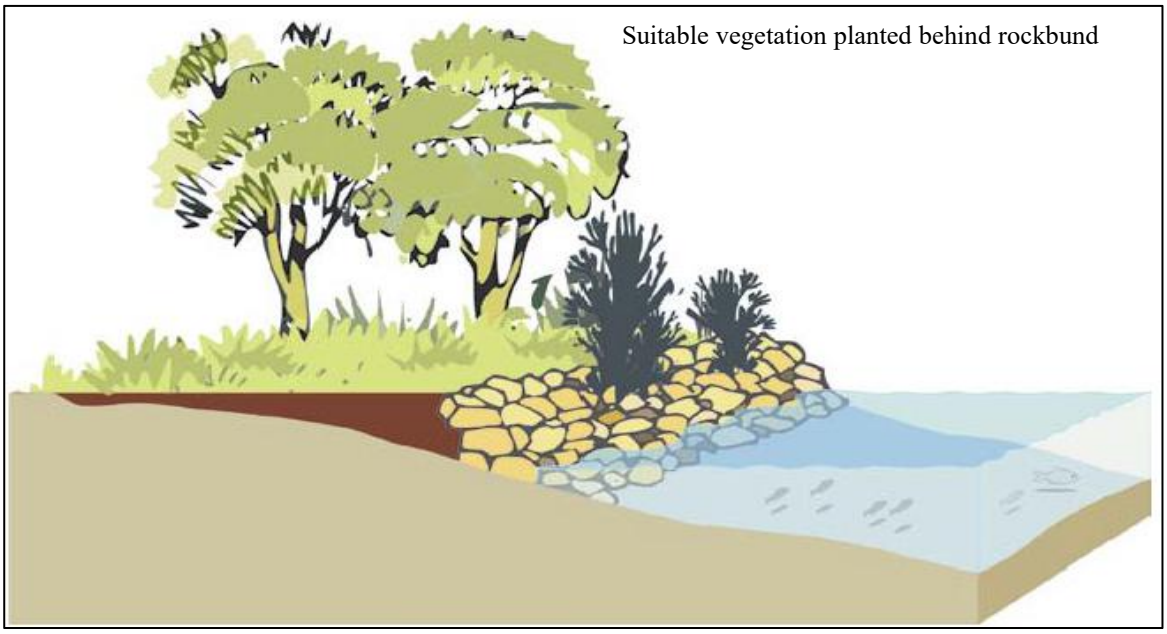
Construction of modified seawalls surrounding the reclaimed area that enable the establishment of mangrove or coastal vegetation. There are several studies (Moosavi, 2017) that have come up with designs that shift from 'coastal armoring' and hard engineered 'defense systems', to ecologically informed infrastructures (eco-engineered structures) that can perform beyond engineering goals and provide ecological and social benefits. Emerging studies determine the importance of ecological knowledge and landscape-based solutions in informing the design of coastal infrastructures; however, there are limited number of projects that demonstrate the most effective design approaches. **Figures 8.6** and **8.7** provide some conceptual drawings of such infrastructure. Details will be part of a separate study that would look at the matter in greater detail.

Figure 8.6: Examples of Shoreline Stabilization by Mangrove Planting



Source: DECC, New South Wales (2009)

Figure 8.7: Examples of Shoreline Stabilization by Coastal Vegetation



Source: DECC, New South Wales (2009)

8.11.2.3 Sea Ranching to Enhance Coastal Food Chain/Web

Sea ranching is an artificial recruitment method where juveniles of the specified animals i.e. shrimp, shellfish and fish, either produced in the hatcheries or caught in

the wild, are released into the natural environment, thus allowing it to grow without any containment structures (Bell *et al*, 2008). As it is released into the natural environment, the animals do not need to be fed, as the environment provides everything that the animals need. The system is meant to improve marine animals stock that is designed to sustain catch by the fishermen (Alban and Boncoeur, 2008; Lorenzen *et al.*, 2010).

In relation with the current study area, sea ranching is recommended to mitigate loss of nursery grounds. The coastal food chain and food web can be enhanced by stocking juveniles of inshore fishes and prawns in the coastal waters fronting the project site. The presence of the established hatcheries within the impact area and/or from the mainland could supply the required post larvae/fingerlings/juveniles. Therefore, it is proposed that the State Government and the hatcheries work together in order to carry out sea ranching. However, it is also pertinent that the stocks released are monitored periodically to assess any impacts arising from the release as well as to ensure other fishermen do not catch the stocks released before it reaches the suitable sizes. The monitoring exercise should be undertaken with the cooperation of the fishermen and Department of Fisheries.

8.11.2.4 Fisheries Research Fund

The Project Proponent shall make contributions to the Fisheries Research Fund to be utilized by Department of Fisheries and/or LKIM for the advancement of the fishing industry in the Melaka.

8.11.3 Marine Habibat

8.11.3.1 Mangrove Replanting and Monitoring Programme

An offset programme should be undertaken by the project proponent to compensate for the impact on marine ecology. The project proponent can work closely with the Melaka Forestry Department in identifying suitable locations along the Melaka coastline. The type of mangrove to be re-planted would depend on specific site conditions and sound geomorphological and hydrological understanding of the

potential replanted sites. It is also recommended that the fishermen and the members of local communities be involved in the re-planting activity, as this would encourage them into taking care of the mangrove and allow them to be the stakeholders, stewards and custodians of the mangroves.

8.11.3.2 Installation of Habitat Enrichment Devices

The reefs at Pulau Besar, Pulau Serimbun, Pulau Terendak and Pulau Burong should be enhanced using artificial substrate to act as habitat enrichment devices. Some of the benefits, according to Pears and Williams (2005), from these devices would include:

- Fishing enhancement (commercial, recreational or artisanal)
- Tourism and recreational opportunity enhancement (diving, snorkelling)
- Science experimentation and research
- Offset for loss of habitat elsewhere
- Conservation of biodiversity (e.g. provide or enhance habitat for re-establishment of depleted organisms)
- Restoration of damaged habitats
- Protection of habitat or control of fishing mortality with artificial reefs as physical barriers

Given the present condition of the islands, the most relevant would be the enhancement of fishing activities. The loss of the mudflat would lead to decrease in catch for the fishermen. The artificial reefs would attract fish to aggregate in the water surrounding the proposed islands, thus reducing the cost of fishing.

Ahmad *et al.* (2013) reported that, 76 species of commercial fish, 33 species coral fish, 7 species of soft coral, 6 species of gorgonians, 9 species of gastropods, 8 species of bivalves, 7 species of sea cucumber, 4 species of sponges and 3 species of echinoderms recorded at artificial reefs installed along the East cost of Peninsular Malaysia. Habitat enrichment, to some measure also mitigates loss of habitat values due to the reclamation of the mudflat area.

8.11.3.3 Turtle Research Fund

Since there are incidences of turtle landings in Pulau Burong and Pulau Lalang in 2011, there is a potential of the turtles to come back and nesting at these areas in the future. These islands are located within the impact zone of the proposed reclamation. Thus, an offset programme should be developed by the project proponent in order to compensate for any impact to the turtles. Funds for turtle-related research or conservation efforts should be allocated by the project proponent.

8.11.4 Fisheries and Aquaculture

8.11.4.1 Suitable Compensation/Ex-gratia

Suitable compensation/ex-gratia should be provided for the fishermen and mussel farming operators operated within the impact zone. Compensation/Ex-gratia will be varied for different fishermen groups and operators based on the severity of project impact to their fishing and farming operations. The eligibility criteria for these benefits should be studied and recommended by a subcommittee formed by LKIM, Department of Fisheries, local fishermen units and the State Government.

8.11.4.2 Ensuring that Fishermen access to Sea will not be Obstructed at Any Time

The Project Proponent should ensure that access to fishing grounds will not be obstructed at any time during the construction and operation period. The layout of the reclamation was established after consideration of fishermen access.

Construction works will be carefully planned such that disruption to fishermen will be minimum. The Project Proponent will closely liaise with the fishermen community prior and during construction process.

8.11.4.3 Employment Opportunities

Due to potential decline of fish catch for fishermen and decline in mussel productions, the project would need to prioritize alternative jobs for the affected fishermen and mussel farming operators.

8.11.4.4 Encourage Recreational Fishing by Providing Designated Areas for Anglers

The proposed Project would have revetments as part of its coastal protection structures. If ecologically informed infrastructure is employed, the structure would attracts several species of fish that are sought after by anglers. As such, the topside development can encourage recreational fishing by providing designated areas for anglers. Findings from this study have shown that recreational fishing generates positive economic and social impacts. In 2018, total economic value for recreational fisheries at the study area amounted to RM1.153 million. Spillover from the increase in recreational fishing activities at study area will benefit the local communities as well as business and boat operators.

8.12 Abandonment

A proper abandonment plan shall be prepared appropriately to ensure all measures are taken care off. If the abandonment occurs during construction, all equipments shall be removed from the site. For any scheduled wastes and solid / liquid wastes available at the site, they must be disposed off in the correct manner at the specified approved areas.